NATIONAL RESEARCH COUNCIL
COMMISSION ON PHYSICAL SCIENCES, MATHEMATICS, AND APPLICATIONS
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PHYSICS AND ASTRONOMY

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February 18, 1993

Ms. Donna R. Searcy
Secretary
Federal Communications Commission
1919 M Street, N.W.
Washington, D.C. 20554

Re: RM No. 8165

In the Matter of

Amendment of the Commission's Rules
with Regard to the Establishment of a
Radio Astronomy Communications Zone
in Puerto Rico

Dear Ms. Searcy:

Transmitted herewith by the National Academy of Sciences—National Research Council's Committee on Radio Frequencies are an original and nine (9) copies of its Comments in the above-referenced proceedings.

If additional information is required concerning this matter, please communicate with this office.

Sincerely,

Robert L. Riemer

Robert L. Riemer
Associate Director

Enclosure

BEFORE THE

Federal Communications Commission

WASHINGTON, D.C. 20554

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Amendment of the Commission's	)	
Rules with Regard to the	)	RM No. 8165
Establishment of a Radio Astronomy	)	
Communications Zone in Puerto Rico	)	

COMMENTS OF THE NATIONAL ACADEMY OF SCIENCES' COMMITTEE ON RADIO FREQUENCIES

February 18, 1993

Direct correspondence to

Dr. Robert L. Riemer
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OFFICE OF THE SECRETARY

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COMMENTS OF THE NATIONAL ACADEMY OF SCIENCES' COMMITTEE ON RADIO FREQUENCIES

I. Summary

The National Academy of Sciences, through the Committee on Radio Frequencies ("CORF") of the National Research Council, hereby submits its Comments on the above-captioned matter. CORF strongly endorses the establishment of a Radio Astronomy Communications Zone in Puerto Rico. CORF's previous comments on proposed rulemaking by the Federal Communications Commission (FCC) have argued consistently for protecting the passive radio astronomy service from harmful interference caused both by transmissions within frequency bands for which radio astronomy is allocated primary or shared status and from out-of-band spurious emissions.

The Radio Astronomy Communications Zone in Puerto Rico proposed in the Petition for Rulemaking submitted by Cornell University[1/] would provide the Arecibo Observatory with timely notice of new services or changes that could generate harmful interference, so that solutions and compromises could be

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1/ Cornell Petition to Request Amendment of the Commission's Rules, November 30, 1992.

investigated before the fact when it is still feasible to resolve most conflicts without incurring large costs for the service provider or the Arecibo Observatory. The proposed Radio Astronomy Communications Zone would not adversely affect existing service providers in Puerto Rico and would not add significantly to the cost or burden of applying for a license to operate a new service or modify an existing license.

CORF believes that the Arecibo Observatory represents a unique resource for scientific research that deserves protection from increased levels of radio frequency interference ("RFI"). CORF urges the Commission to establish a Radio Astronomy Communications Zone in Puerto Rico and take into consideration the potential effects on the Arecibo Observatory during its licensing procedures as one significant step toward achieving such protection.

II. The Research and Public Value of the Arecibo Observatory

The Arecibo radio telescope is the largest single radio/radar telescope operating in the world today. Built in the early 1960s with federal funds, it is now part of the National Astronomy and Ionospheric Center, operated by Cornell University under a cooperative agreement with the National Science Foundation. Its $7.5 million annual operating budget is provided by the National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA). Because of its great size, the low-noise receivers with which it has been instrumented, its powerful radar

transmitters, and the unique analog and digital signal detection equipment at the observatory, Arecibo is capable of routinely performing scientific observations that cannot be carried out anywhere else in the world. This facility is a source of considerable pride within the United States scientific community and for the residents of Puerto Rico. The cost of construction of the telescope in today's dollars would exceed $100 million, and there is no other U.S. territory outside of Puerto Rico, at latitudes sufficiently close to the equator, to permit the effective functioning of this singular spherical telescope design.

Currently, the Arecibo Observatory is engaged in the Gregorian Upgrade Project, costing $22.8 million (furnished by the NSF and NASA), which will increase the average sensitivity of the telescope by a factor of 3 and the speed with which data can be acquired by a factor of 10. This upgrade allows for the potential of new discoveries and more scientists being able to use the facility during its 24-hour-per-day, 365-day-per-year operation.

Located 17 kilometers south of the city of Arecibo, the observatory's isolated mountain location originally provided some natural protection from the sources of RFI present 30 years ago when the telescope was constructed. Since that time, the island of Puerto Rico has become the second densest region of licensed transmitters in the United States.

The telescope's main dish is a spherical reflector 305 meters in diameter, and the platform supporting the feeds and receivers is suspended by cables 137 meters above the reflector. While the main antenna beam and near-in sidelobes remain shielded by the terrain immediately surrounding the reflector, the far-out sidelobes overlook the surrounding hills and view the entire island of Puerto Rico. At most frequencies, the present sensitivity of these far-out sidelobes is 80 dB below that of the main antenna beam. Nevertheless, strong sources of RFI, such as those associated with airport radar beacons at the San Juan Airport, require special countermeasures, e.g., turning off the data collection when the radar beam is pointed at the observatory.

The observatory has been very resourceful in its efforts to limit damage done by known sources of interference that operate on predictable schedules and constant frequencies, and is expected to continue doing so in the future. For example, the Gregorian focus cabin incorporates a metallic dome to shield the feeds and receivers from all RFI except that reflecting off the platform down into the spherical reflector, and studies are being made to see whether these reflections can be reduced by "stealth" techniques. However, if RFI continues to grow as a result of increases in the power density, the number of transmitters, and frequencies utilized, the Arecibo Observatory will exhaust ways to protect itself, and the amount of corrupted scientific data will increase. Ultimately the scientific potential of the

observatory and the Gregorian upgrade will be compromised beyond repair. If the observatory is not protected, what will be lost?

Over the years the Arecibo Observatory has used its powerful radar transmitter to map the surfaces of Venus, the Moon, and Mars with a precision that was not bettered until spacecraft were sent to orbit these bodies. During 1992, for example, the radar detected an icecap on the south pole of Mercury (where there are no plans to send spacecraft), and it discovered the binary nature of the Earth-orbit-crossing asteroid Toutatis, which is only 3.5-kilometers long.

In the field of atmospheric science, the large collecting area of Arecibo Observatory, in conjunction with low-frequency transmitters elsewhere on Puerto Rico, provides a unique capability for exciting various components of the stratosphere and studying them with extremely fine vertical height resolution and velocity discrimination. Because of its location at a low latitude along a common line of longitude with other atmospheric observatories, the Arecibo Observatory routinely provides valuable data to World Day atmospheric observing campaigns.

The observatory has become the premier site for the detection and precise timing measurements of pulsars. The detection of a millisecond pulsar in 1983 opened an entire new area of scientific exploration and led to our tentative understanding of how old pulsars in binary systems can be "recycled" and spun up. The detection of the Hulse-Taylor binary pulsar system allowed the validation of Einstein's theory of gravitational radiation.

Precise timing of the arrival of individual pulses from one millisecond pulsar have revealed the presence of two Earth-mass bodies in orbit around the pulsar. This unexpected detection of extrasolar planets in such an astrophysically unusual environment may help us answer some of the open questions about the formation of our own solar system. The high sensitivity of the observatory makes it the instrument of choice for conducting large-scale searches for distant pulsars in the galactic plane and in the globular clusters high above the plane. The easy detections have already been made, and Arecibo's upgraded sensitivity will enable the remaining explorations.

Certain molecules, such as the hydroxyl radical, occur in dense gas clouds or in the extended atmospheres of giant stars, which emit extraordinarily bright, amplified spectral lines. These natural masers have been studied in regions throughout the Milky Way Galaxy, but only Arecibo's sensitivity can detect similar emission in external galaxies.

Of all the interesting science that is possible at the Arecibo Observatory, it is the study of atomic hydrogen gas in our galaxy and across the universe that claims the largest share of observing time. Because of its high sensitivity, the Arecibo Observatory can detect hydrogen emission signals from the farthest reaches of our universe, which are at the earliest epochs of galaxy formation. Because the farthest galaxies are receding from us at the fastest speeds, their hydrogen emission signals undergo the largest red shifts to lower frequencies.

When the 1400-1427 MHz band was allocated to radio astronomy on a primary basis for neutral hydrogen studies, neither scientists and regulators appreciated that distant hydrogen signals would eventually be detected down to red-shifted frequencies as low as 432 MHz. Such low frequencies, being in proximity to allocated broadcasting services, pose an exceptional challenge to observers at Arecibo. Nevertheless, the sensitivity of this observatory provides a window on the most distant, earliest realms of the cosmos, and scientists will continue to devise schemes for circumventing the extremely loud terrestrial signals arriving at the observatory at the frequencies of interest, to the degree that this is technically possible and affordable.

The technology required to make a systematic search of the entire microwave window for narrowband emission indicative of extraterrestrial technologies was not in hand when the current frequency allocations were made. Today it is, and Arecibo is a key component of NASA's High Resolution Microwave Survey ("HRMS"). High sensitivity is the key to success in this endeavor, and at Arecibo all frequencies from 1 to 3 GHz will be explored. The HRMS is optimized for the detection of signals that contain coherent components, which are unknown in nature but are plentiful in our own technology, and therefore the HRMS is particularly susceptible to RFI. Much of the instrumental complexity and cost inherent in the signal detection hardware is driven by the need to recognize and exclude terrestrial RFI. It

remains to be proven whether this hardware is adequate to overcome increased levels of terrestrial RFI.

The foregoing discussion has emphasized the scientific return from use of the Arecibo Observatory, but the technological innovations that radio astronomy has spawned should not be forgotten. The staff of the National Radio Astronomy Observatory[2/] have amply documented radio astronomers' development of technology that subsequently enabled commercial capabilities. As the sensitivity of Arecibo improves as a result of the Gregorian Upgrade Project, it can be confidently predicted that some of the new technology, developed to enable the science at the site, will find applications in commercial services. Moreover, the special work-arounds and avoidance techniques developed by the observatory to protect its scientific observations may well provide useful methodologies to other services competing for use of, or sharing, scarce frequencies.

The history of astronomy shows that the most astonishing scientific discoveries are those that are completely unpredicted! This history also demonstrates that such discoveries are inevitable with each increase in telescope sensitivity, and they can be missed in an environment with increased interference. The heritage of scientific discovery is sufficient reason to support efforts to ensure that the Arecibo Observatory is capable of

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2/ *New Technology Fostered by Radio Astronomy*, National Radio Astronomy Observatory, Charlottesville, Virginia, July 1990.

exercising the new capabilities conferred in the Gregorian Upgrade Project.

Arecibo Observatory has recently broken ground for a Visitor and Education Center that promises to benefit the people of Puerto Rico. It should increase the number of visitors to the site from 50,000 per year to 100,000. The majority of visitors are Puerto Rican school children, but the site is also a major tourist attraction. The Commonwealth of Puerto Rico has shown strong support for the Arecibo Observatory and its new educational facility by establishing a 4-mile-radius Communications Zone around the observatory as part of the recent changes in zoning law.

III. The Commission Should Establish a Communications Zone in Puerto Rico for the Benefit of Arecibo Observatory

CORF urges the Commission to establish a Radio Astronomy Communications Zone in Puerto Rico. Such a zone would have no adverse consequences for existing active services in Puerto Rico. As is the case with the existing National Radio Quiet Zone ("NRQZ") in Virginia, West Virginia, and Maryland and the Table Mountain Receiving Zone in Boulder, Colorado, the Radio Astronomy Communication Zone in Puerto Rico would require all applicants for new FCC licenses and applicants for modifications to existing licenses to notify the Arecibo Observatory at the time of the application. The Arecibo Observatory would then have 20 days in which to provide comments on the potential for harmful interference from the requesting licensee. This administrative

requirement offers the potential for improved cooperation between the Arecibo Observatory and the active users of the spectrum. At an early stage, before construction has begun, there are many ways in which the power, directionality, and out-of-band emissions of a proposed service could be modified to protect the Arecibo Observatory without substantially degrading performance, or increasing the cost of the new service. The notification procedure requested could potentially save significant amounts of money and time while avoiding the necessity of pleadings before the Commission to correct problems discovered only after the fact, as in the case of WCCV-TV. The Commission, in deciding how to allocate the spectrum to best serve the public, would have available the added information on potential adverse effects on the Arecibo Observatory to include in its deliberations.

It could be argued that the current procedure for applying for a new license or modifying an existing license is public and that Arecibo Observatory could arrange to have access to these filings without the establishment of a Radio Astronomy Communication Zone for Puerto Rico. In practice, monitoring the current procedure for all filings in Puerto Rico would require the employment of professionals who can provide this service. Monitoring would place a financial burden on the Arecibo Observatory, whose budget is limited. On the other hand, compliance with the terms of the proposed Radio Astronomy Communications Zone in Puerto Rico would impose little or no fiscal burden on those applying for new or modified licenses. CORF argues that the establishment of a Radio

Astronomy Communication Zone is in the best interest of all parties wishing to make use of the radio spectrum in Puerto Rico, and urges the Commission to act favorably on the Petition for Rulemaking that has been submitted by Cornell University on this matter.

Respectfully submitted,
THE NATIONAL ACADEMY OF SCIENCES

By: 
Frank Press
President

February 18, 1993

Please serve:

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